CDM

Technical Memorandum

To: *Department of Public Works*
Henrico County, VA

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Subject: *Chesapeake Bay TMDL Compliance Cost Evaluation*

As EPA and the Commonwealth of Virginia develop their Chesapeake Bay TMDL and Watershed Implementation Plan (WIP), respectively, to address pollutant concerns in the Chesapeake Bay, a consideration of the potential cost impacts related to stormwater for localities and their citizens is appropriate but has generally been omitted to date. This memorandum summarizes approaches to attempt to estimate the cost for implementation of stormwater retrofits to comply with the EPA Draft TMDL for the Chesapeake Bay (September 24, 2010). It should be noted that site specific conditions, technologies, and local regulations may affect the application of this cost analysis. Therefore, a variety of methods and associated range of costs is provided for consideration and planning purposes. Using these methods described below and applied to Henrico County, EPA's Draft Bay TMDL requires a 43.8% total nitrogen (TN) reduction, a 47.8% total phosphorus (TP) reduction, and a 48.4% sediment (SED) reduction. Furthermore, the TMDL is estimated to have an Annual Per Household Cost Impact in the range of $520 per year per household initially up to a potential maximum impact of $1,560 per year per household in 2025.

1.0 Calculation Methodology

As the TMDL is in "draft" form and uncertainties in the Bay model and input data may exist, this technical memorandum estimates the cost impacts using a variety of methods in an effort to provide a range of costs. The following sections summarize the assumptions used for each calculation method:

Method 1 – Analysis of Capital Cost by Treated Acres

The first method used to estimate the stormwater retrofit/treatment capital cost involves the application of unit costs (based on treated area) to specific areas as defined by Virginia and EPA within the draft Virginia WIP and draft EPA TMDL. The following subsections describe the cost evaluation and estimate of treatment area:

Unit Cost Assumptions

A literature search was performed to determine estimated costs for pollutant reduction. One of the most common costs listed for the subject matter includes the cost to treat a unit of area (e.g, per acre, etc). It is anticipated that high-efficiency, BMP retrofits will be required to meet the reduction goals set forth by the State and EPA in the respective documents. The Center for Watershed Protection (2007) reports an average construction cost of approximately $88,000 per impervious acre (or, approximately $90,000 in 2010 dollars) to treat for pollutant removal using higher efficiency BMPs. Treatment of pervious land is less costly and has been estimated to be approximately $4,100 per pervious acre (2010 dollars). These costs can be applied to the treatment area in any locality to determine a planning level cost for pollutant reduction.

It has been estimated that full delivery cost is approximately 50% higher to account for engineering, design, permitting and contingency of such projects, bringing the cost to approximately $135,000 per impervious acre and $6,150 per pervious acre (each in 2010 dollars).

Treatment Area Determination

The draft TMDL released by EPA proposes aggressive performance standards to meet the urban stormwater load reduction targets. Page 9 of the Executive Summary of the Draft Chesapeake Bay TMDL summarizes the assumptions related to nutrient reduction in MS4 areas, including proposed treatment for 50 percent of urban MS4 lands through retrofit/ redevelopment and treatment for 50 percent of unregulated land treated as regulated (thus suggesting a 25 percent treatment of unregulated land). Based on a review of the model, "regulated lands" are noted as a combination of "high intensity impervious", "high intensity pervious", "combined sewer system", "bare construction" and "extractive" areas. "Non-regulated lands" are a combination of "low intensity impervious" and "low intensity pervious." These assumptions form the basis of EPA's "Backstop Allocations" defined in the EPA's WIP. It is stated that these assumptions are the basis of a scenario approaching E3, which has been defined as "everything, everywhere by everyone."

The latest available model runs from EPA dated 09/17/10 list the total acres used for each locality. Data specific to Henrico County was used for this evaluation. Table 1 summarizes the urban acres, as defined in the model, for Henrico County.

Table 1 – Urban Land Use Breakdown for Henrico County

Land Use	Designation	Urban Acres	% Treated	Treated Acres
High Intensity Impervious	Regulated	10,042	50%	5,021
Low Intensity Impervious	Unregulated	106	25%	27
Combined Sewer System	Regulated	1,193	50%	597
High Intensity Pervious	Regulated	39,763	50%	19,882
Low Intensity Pervious	Unregulated	1,244	25%	311
Total		**52,348**	**n/a**	**25,837**

The unit cost factors previously provided were applied to each respective land use category (impervious or pervious). For the Combined Sewer System area, a breakdown of the percentage of pervious and impervious is not provided. CDM assumed an equal split of the two areas for cost determination. Refer to Section 2.0 for the cost summary.

Method 2 – Analysis of Capital Cost by Pollutant Reduction

A second method used to estimate the stormwater retrofit/treatment capital cost is an evaluation of the cost to remove a unit weight or volume of a pollutant. The following sections summarize the assumptions used to generate a retrofit cost for this method.

Unit Cost Assumptions

Total nitrogen (TN) and/or total phosphorus (TP) are significant pollutants of concern for the Bay. The unit costs are typically reported in dollars ($) per pound, per year removed. Similar to the first method, research and literature shows varying levels of cost for pollutant reduction (Florida DEP, 2010). Documented costs for completed retrofit projects designed to specifically treat nutrients were compiled to form the basis for this method. The State of Florida Department of Environmental Projection (FDEP) tracks the pollutant removal costs of all projects that receive State Revolving Loan funds. The State has summarized the costs for over 40 projects at the link provided herein:
http://www.dep.state.fl.us/water/watersheds/docs/tmdl-grant-nutrient-costs-0210.pdf.

For the purposes of this work, the following assumptions were made regarding the FDEP data:

- TN removal was used as the basis for calculating nutrient removal costs. This assumption was used for a factor of safety as the majority of BMPs are credited with a lower TN removal efficiency than respective TP and total suspended solids (TSS) removals. For instance, the NC BMP Manual credits wet ponds with a 25% removal of TN, a 40% removal of TP, and an 85% removal of TSS. assumed to require the greatest level of effort, and was

- Of the 40 projects in the Florida DEP study, the top and bottom 10th percentile values were screened out in order to remove the potential for outlier data points.
- To account for the potential difference in cost when comparing BMPs in Florida soils versus soils in Virginia, only the top half of the remaining data points were used to compute average cost values.
- The average cost for TN removal is $8,040 lb/yr.
- Similar to the previous scenario, a factor of 50% was applied to all final costs to account for design, permitting and contingency.

Pollutant Removal Determination

The Chesapeake Bay TMDL model run output spreadsheets include both baseline (assumed 2009 Progress) and target load allocations for individual municipalities. The most recent backstop allocations can be found in the model run dated September 17, 2010. Table 3 summarizes total nitrogen baseline loadings and backstop allocation target load reductions for Henrico County.

Table 3 – Target TN Load Reductions for Backstop Allocations

Baseline Loadings (lbs/yr)	Edge of Stream TN(lbs/yr)
Impervious	106,322
Pervious	249,303
Total	**355,626**
Reduction (Lbs/yr)	**Edge of Stream TN (lbs/yr)**
Impervious	43,004
Pervious	112,772
Total	**155,777**
Reduction (%)	**Edge of Stream TN (% removal)**
Impervious	40.4%
Pervious	45.2%
Total	**43.8%**

The estimated cost on a pounds per year basis defined above for TN was applied to the TN reduction target in Table 3 to estimate the total retrofit cost for TMDL compliance. The cost for this method is reported in Section 2.0 in comparison to the other calculation methods described herein.

Method 3 – Analysis of Capital Cost by BMP Implementation

The third method used to estimate the stormwater retrofit/treatment capital cost is based on the potential number of BMPs required to achieve the required pollutant load reductions. The following sections summarize the BMP cost analysis and application of BMPs to Henrico County.

Unit Cost Assumptions

For the third method of this work, it was assumed that traditional stormwater wet ponds would be used to provide the treatment necessary for the target nitrogen load reduction. Wet ponds are the most common and least cost BMP for treating nutrients in any soil condition, and our estimated cost represents a baseline planning level cost. Actual implementation depends on watershed, locality, site specific conditions and could be higher than these planning level costs if other types of BMPs are needed due to site constraints.

It was assumed that semi-regional ponds would be installed as retrofits and serve 50-acres each. Wossink and Hunt (2003) provide standard equations for determining the construction cost of typical BMPs based on area treated. For a stormwater wet pond, the following equation was used to estimate the total construction cost:

$$\text{Cost (in 2003 dollars)} = 13{,}909 \times DA^{0.672}, \text{ where DA = drainage area in acres}$$

The cost was computed in 2010 dollars using an annual inflation rate of 4%. In addition, the Wossink and Hunt study suggests that the cost for a retrofit BMP versus a new BMP ranges from 1.5 to 4 times the new construction cost. Therefore, a factor of two was applied to the cost calculated in 2010 dollars. Finally, the standard factor of 50% was applied to account for design, engineering, permitting and contingency cost. The estimated cost (in 2010 dollars) to construct a retrofit, stormwater wet pond that treats 50 acres is $508,000.

Wet Pond Implementation Determination

Per the previous section, 155,777 lbs/yr is the targeted TN load reduction necessary to meet EPA's Backstop Allocation Scenario for Henrico County. Several assumptions are required in order to determine the total number of wet ponds necessary to achieve the targeted load reductions. The following list describes these assumptions:

- Based on a review of the EPA model runs for the Bay, the "No Action" pollutant loading rate for TN is shown to be approximately 10 lbs/ac/yr.
- If the pond is assumed to treat 50 acres, then the pollutant load delivered to each pond is 500 lbs/yr.

- Supporting documentation for the model input states that wet detention ponds have a removal efficiency of 20 percent. When applied to the 500 lbs/yr, each wet pond serving 50 acres can remove approximately 100 lbs/yr of TN.

- If a reduction of 155,777 lbs/yr is the target, then approximately 1,560 wet detention ponds are required to achieve the total reductions.

The total number of ponds required to meet the reduction goals can be multiplied by the cost per wet pond defined above to calculate the total cost of BMP implementation. This cost will be defined and compared to the two previous methods in the Section 2.0.

It should be noted that 1,560 wet detention ponds would treat approximately 78,000 acres (1,560 x 50 acres/pond). While Table 1 shows only the urban acres at 52,348 acres, the total acreage for Henrico County is 156,800 so this method is feasible in theory. However, further evaluation on land availability and acquisition opportunities would have to be performed at the local level to determine the true cost of implementation.

2.0 Total Cost Comparison

The three calculation methods above were applied to Henrico County data that resides in the Chesapeake Bay TMDL model to validate the process and to define a potential range of costs for planning/implementation. Table 4 presents a summary of the estimated total construction cost (including design, engineering and permitting considerations) to achieve the targeted loads listed in the model runs for Henrico County. Ongoing operation and maintenance (O&M) cost of the new BMP facilities should also be considered. For this, a standard industry value of five percent of the capital construction costs is used to estimate annual O&M costs, which is then totaled for the 15 year planning period assumed for Bay TMDL compliance. The total O&M cost for the 15-year period is also provided in Table 4.

Table 4 – Planning Level Estimate of BMP Retrofit Costs for Henrico County, VA based on EPA Draft Chesapeake Bay TMDL (in 2010 dollars)

Method	Total Capital ($)	Total O&M ($)	Total Cost ($)
1 – Cost By Treated Acres	$ 848,000,000	$ 297,000,000	$ 1,145,000,000
2 – Cost By Pollutant Reduction	$1,252,000,000	$ 438,000,000	$ 1,690,000,000
3 – Cost by BMP Implementation	$ 1,189,000,000	$ 416,000,000	$ 1,605,000,000

Based on the assumptions provided herein, the range of total capital costs for Henrico County is approximately $848 million to $1.25 billion for full implementation of BMP retrofits through 2025 (15-year planning period).

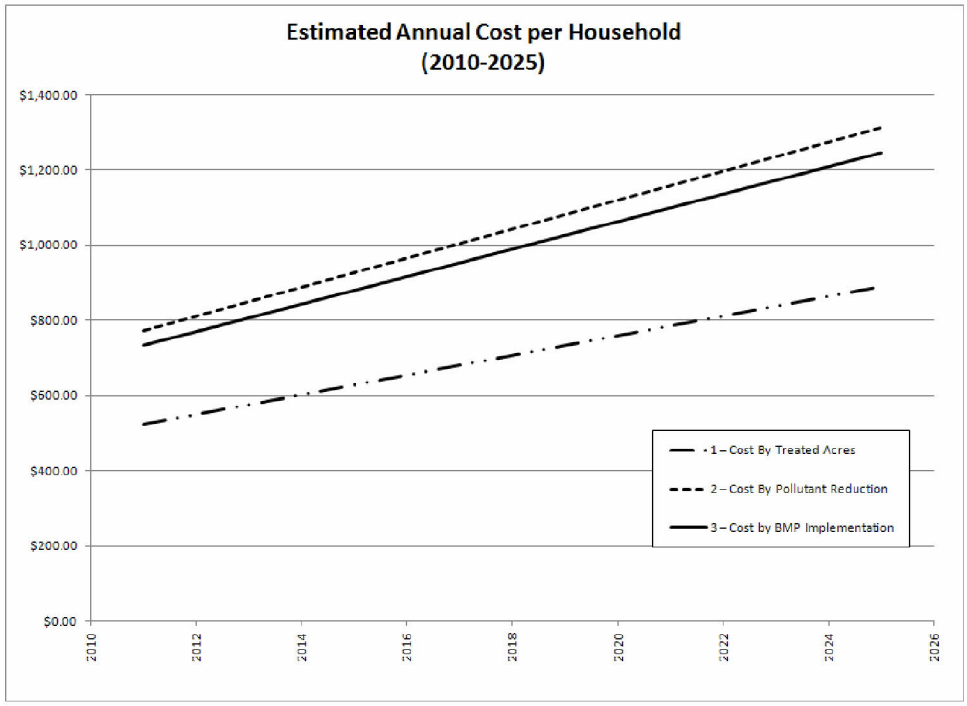
It is important to note that the capital costs indicated do **not** include master planning costs and any costs/fees associated with land acquisition, land attainment, transfer of land ownership, etc. associated with wide implementation of various BMPs across the county. Therefore, land costs (such as acquisition costs for some or all of the 1,560 wet pond sites) would increase the capital costs presented herein.

It should also be noted that capital costs on this order of magnitude would typically be bonded and the debt service paid over time, so the financial burden shown in the table above should not be interpreted as requiring upfront lump sum investment. Section 3.0 graphically depicts a possible scenario that Henrico County may experience on an annual basis.

3.0 Estimated Cost per Household/Person Annually

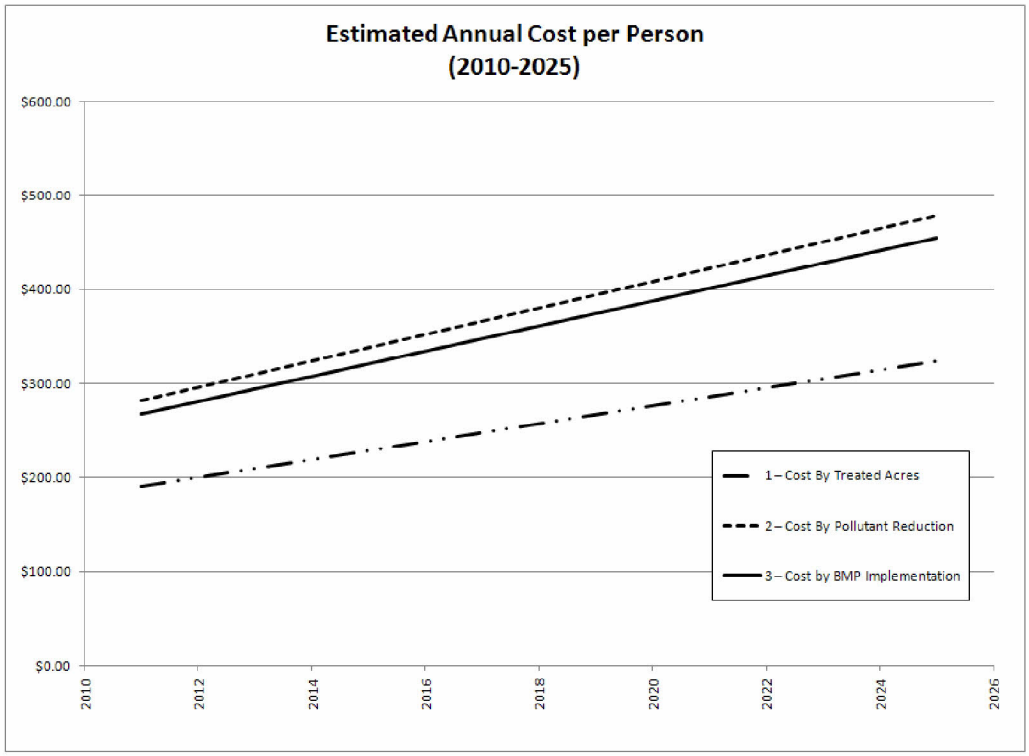
As a final evaluation, CDM estimated the potential cost on a household basis and a per person basis for Henrico County based on 2009-2010 US Census Bureau data (296,415 population and 108,121households). The following charts assume that capital costs for BMP implementation are normalized each year and that over time O&M costs will increase per year due to more BMPs being in service each year. In summary, costs per household per year range from a low of $520/year initially up to a potential maximum of $1,310/year in 2025 depending on the methodology used and the annual O&M costs.

Chart 1 –Estimated Annual Cost per Household (2010 dollars)



When evaluating the cost by population, the costs per person per year range from a low of $190/year initially to a potential maximum of $480/year in 2025 depending on the methodology used and the annual O&M costs.

Chart 2 –Estimated Annual Cost per Person (2010 dollars)



While the costs per household and per person are high, coordination between County departments and/or other units of local government may decrease the actual cost. For instance the Virginia Department of transportation (VDOT) may coordinate with Henrico County to achieve nutrient reductions, thereby reducing the total cost per household. Likewise, neighboring cities and counties may coordinate to achieve the new TMDL. However, even with a substantial reduction in total cost, the proposed cost impacts may pose a potential financial burden on homeowners.